The NASA Heritage of Creativity

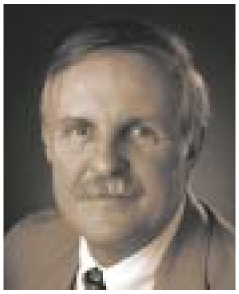
2003 ANNUAL REPORT of the NASA INVENTIONS and CONTRIBUTIONS BOARD

The NASA Heritage of Creativity

Message from the Chair

Although the audience for this report is most directly our colleagues from the NASA technology community, this year's report also contains several items of interest to the rest of our Nation. NASA's Inventions and Contributions Board (ICB) serves as a reporter of the health of NASA's research, development, and demonstration (RD&D) community. I am happy to say categorically that our engineers, scientists, mathematicians, and software developers, representing over 100 disciplines in these arts, are alive, well, and productive. This year represents a record crop of fresh, new ideas from the community. The quality and quantity of NASA innovations have never been greater. With the extraordinary challenges that NASA has been given in our charter, our technologists have responded with imaginative yet practical solutions, collectively making it possible to extend the boundaries of knowledge in nearly every field of endeavor. The NASA heritage of creativity sparks afresh each day.

As one reads through the chronicle of these achievements, one can only feel pride in these people and their accomplishments. The ICB stands ready to reward the best and brightest with the peer recognition they deserve, as well as a token monetary award. I urge every one of you to continue to be creative, to report your new ideas, and to become a leader within your field. It is expected of you. I hold our management accountable to encourage the technologists under their leadership by strongly supporting the Space Act Awards Program. It is a win-win-win situation: for the innovators, for NASA, and for the Nation.



Theron M. Bradley, Jr.
NASA Chief Engineer and Chair of the ICB

The First ICB in 1958, from left: Dr. James A. Hootman, Executive Secretary; Paul G. Dembling, Vice Chair; Dr. T. Keith Glennan, NASA Administrator; Elliott Mitchell, Member; Robert E. Littell, Chair; and J. Allan Crocker, Member. Not Pictured: C. Guy Ferguson, Member.

HISTORY

On December 4, 1958, exactly 14 months after the Russians successfully launched Sputnik I and officially engaged the space race, the Inventions and Contributions Board (ICB) was activated to meet the obligations set forth in the Space Act of 1958.

The first ICB (pictured above) was described by the first NASA Administrator, T. Keith Glennan, as "those poor devils" because they had over 1,000 award applications awaiting action even before they met!

Since that frenetic beginning, the ICB has met over 400 times and has disbursed over 83,000 awards totaling more than $29 million (in 2003 dollars) to scientists, software designers, mathematicians, engineers, and technicians for their contributions to NASA's space and aeronautics activities.

Lyndon Johnson presides over a Space Act awards ceremony at NASA Headquarters in early November 1963.

ACHIEVEMENTS

These awards have chronicled a history of technology achievement unrivaled in its richness, timeliness, value, and innovation.

In early November 1963, 3 weeks before he became President, Lyndon Johnson presided over a Space Act awards ceremony at NASA Headquarters (pictured opposite left) to recognize some of NASA's inventions, including many that had led to triumphs, break-throughs, and successes with aviation and human space flight.

Human Space Flight

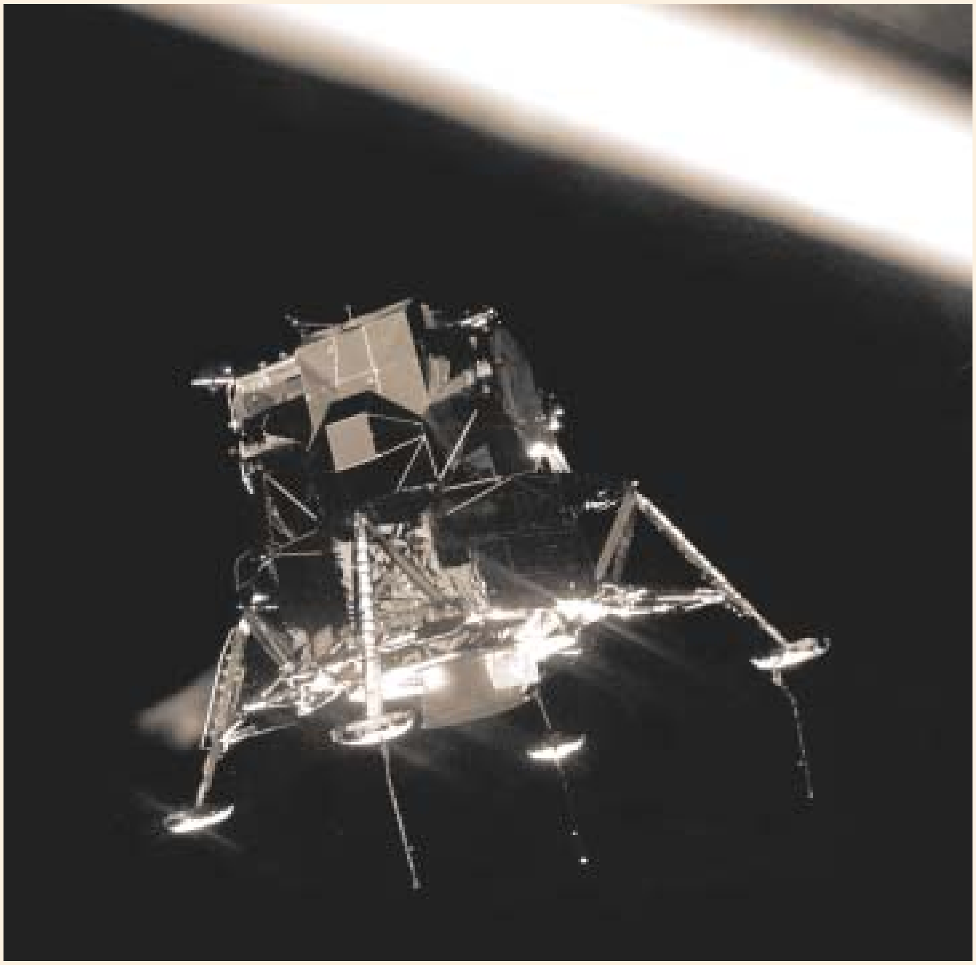
The Mercury capsule, an invention of Maxime Faget and colleagues, had many fascinating features that contributed to the early successes in human space flight, such as an escape system that could pull the capsule away from the Atlas launch vehicle if there was a mishap. Faget was also one of the key designers of the Space Shuttle just a few years later.

Atlas Launch with John Glenn in the Mercury capsule on its way to orbit, February 20, 1962.

Gemini brought about the first spacewalks and the ability to perform extravehicular activities (EVAs) with spacesuits designed for that purpose.

Apollo was the mission that defined NASA for 14 of the first 18 years of its existence. The confluence of great ideas, inventions, and contributions became the hallmark of its success.

Although Apollo I brought our first fatalities, the NASA family of technologists learned from the mistakes and marched on toward the future with still greater determination.

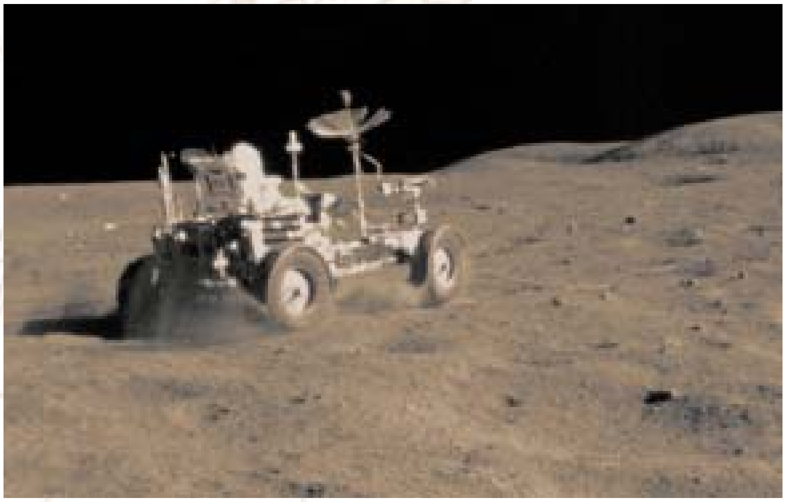


This is a photo of the Apollo 11 Lunar Module (LM) Eagle taken 20 minutes before landing on the Moon on July 20, 1969. The photograph was taken by Command Module pilot Mike Collins. The long, rod-like protrusions under the landing pods are lunar surface sensing probes. Upon contact with the lunar surface, the probes send a signal to the crew to shut down the descent engine.

Apollo's greatest achievements are in the fields of software design and engineering, computer systems miniaturization and design; materials development (coatings and shielding, plastics, and ultra-high-temperature refractory materials); guidance, navigation, and control; propulsion systems (large-scale rocket motors); environmental control; ultra-high-reliability hardware manufacture and software integration; wireless digital telecommunications; data encryption; hand-held video cameras; electromechanical actuators that work in space (such as on the lunar rover—see opposite top); analog-to-digital converters; and electronic programmable read-only-memory devices—and the list goes on.

One of the last Apollo missions was the launch of Skylab, the world's first space station (pictured below,) where men learned to live and work in space for extended periods.

Skylab was launched on May 14, 1973, with humans aboard during May 25–June 22, 1973; July 28–September 25, 1973; and November 16, 1973–February 8, 1974. The last Saturn rocket was used for the Apollo-Soyuz mission, July 15–24, 1975. Five years and 8 months went by after the end of Apollo before humans reentered space with the Shuttle (see a simulation of the Shuttle launch configuration on the next page), which allowed men and women to return to Earth in a controlled glider that could literally land in front of a reviewing stand. The Shuttle has successfully completed 111 flights.



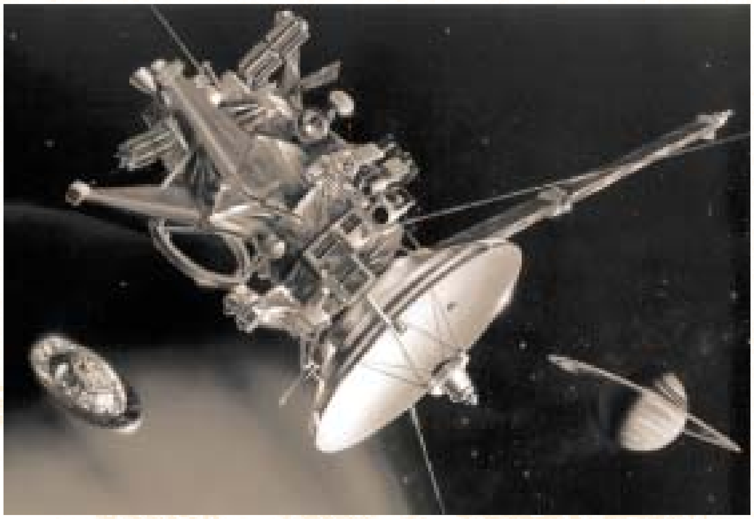
The lunar rover on Apollo 16, April 23, 1972, on its third EVA, piloted by veteran astronaut John Young.

Skylab, the world's first space station, where men learned to live and work in space for extended periods.

Simulation of the Shuttle launch configuration using NASA's OVERSET Computational Fluid Dynamics (CFD) tools.

Robotics

Robotic spacecraft have run a course of space exploration parallel to that of crewed spacecraft. A host of ideas have made these missions reliable sources of rich scientific and commercial content. Beginning with Echo, a large number of weather, navigation, Earth observation, telecommunications, and deep space missions (see Cassini spacecraft and Pathfinder Mars rover on the next page) have proven new technologies that have created new wealth and technology leadership for our Nation.



Cassini spacecraft on its mission to Jupiter and Saturn. Cassini will launch humanity's first probe into the atmosphere of Titan, the Earth-like moon of the planet Saturn, on December 25, 2004.

Mars planetary rover on the Pathfinder mission. The Sojourner explored the surface of Mars for over a month and electrified the world with Web access to its data as they arrived on Earth.

Aircraft and Aviation: Aeronautics

Some of NASA's most valuable inventions have been in aeronautics. Good examples have been the Ragallo wing (the hang glider), the supercritical airfoil (for near-sonic flight conditions), the airborne windshear hazard risk factor (F-factor), advanced aircraft engine design, cost-minimized aircraft trajectories, and automated air traffic control aides. Many of the early achievements of the National Advisory Committee for Aeronautics (NACA) are related to aircraft, airfoils, helicopters, and studies of the properties of the atmosphere, upon which NASA has built in the modern era. Aviation safety is one of NASA's focus areas or themes, and one of this year's exceptional cases, the cabin pressure monitor (shown on this page), is a good example of a contribution to this field.

Jan Zysko (left) and Rich Mizell (right) test a Personal Cabin Pressure Altitude Monitor.

Value

For the past 45 years, NASA's technology achievements have extended the breadth and range of scientific exploration in virtually every field of endeavor and every technical discipline. NASA's patents represent 1 out of every 1,000 patents that have been issued since 1790. Only about 10,000 technologists work for NASA, and perhaps 40,000 more in the private sector contribute to our missions. This statistic shows that NASA's family produces new ideas 100 times more frequently than average.

As NASA progresses into the future, the heritage of our past successes sets a benchmark for future explorers and inventors that will be difficult to surpass.

If we value these ideas in today's currency, the total would likely exceed $300 billion (see chart at right reflecting human space flight contributions recorded in the last 12 years).

Human Space Flight Contributions to Society (see *http://icb.nasa.gov/excp.htm*)

EXCEPTIONAL AWARD CASE NUMBER	TITLE	VALUE
MFS-04163-1	Meteorological Balloon	$1 billion+
MSC-21293-1	Rotating Bioreactor Cell Culture Apparatus	$100 million+
GSC-00092-1	NASTRAN Efficiency Improvements and Enhancements	$10 billion+
MSC-21763-1	Regenerable Biocide Delivery Unit	$100 million+
KSC-11612-1	Space Shuttle Ground Processing Scheduling System (GPSS)	$200 million+
LEW-16018-1	CARES/Life—Ceramic Analysis & Reliability Evaluation of Structures Life	$50 billion+
ARC-12121-1	INS3D—An Incompressible Navier-Stokes Solver in General 3D Coordinates	$1 billion+
MSC-21208-1	CLIPS—C-Language Integrated Production System.	$3 billion+
KSC-11767-1	Windows Visual News Reader (WINVN)	$1 billion+
ARC-13316-1	Flow Analysis Software Toolkit (FAST).	$100 million+
JSC-00095-2	Information Sharing Protocol (ISP)	$1 billion+
KSC-11614-1	Real-Time Non-Volatile Residue Monitor.	$100 million+
ARC-14249-1 LE	OVERSET Tools for CFD Analysis.	$3 billion+
LEW 00098-1	Tempest.	$1 billion+
DRC-096-034-1	Ring Buffered Network Bus Data Management System	$1 billion+
JSC-99-04	Radiation Susceptibility Assessment of NASA Flight Hardware Using High-Energy Protons	$100 million+
KSC-11959-1	Enhancement of Zero-Valent Metal Treatment of Chlorinated Groundwater by the Use of Ultrasound	$100 million+
KSC-11884-1	A New Process and Equipment for Conversion of NOx Scrubber	$100 million+
KSC-12302-1	LNG Tank Gauging System	$1 billion+
KSC-12168-1	Personal Cabin Pressure Altitude Monitor and Warning System (CPM)	$100 million+
LEW-14072-1, 2, & 3	Atomic Oxygen Protective Coatings for Solar Array Blankets	$15 billion+
MSC-22424-1, MSC-22822-1, & ARC-14087	Rotary Blood Pump (Ventricular Assist Device—VAD).	$10 billion+
ARC-14275-1	Cart3D: A Package for Automated Cartesian Grid Generation and Aerodynamic Database Creation	$100 million+
KSC-11009-1	Implantable Digital Hearing Aid	$3 billion+
MSC-23445-1	The DSMC Analysis Code (DAC) Software for Simulating Rarefied Gas Dynamic Environments	$100 million+
MFS-31243-1	Video Image Stabilization And Registration (VISAR).	$300 million+
MSC-23567-1	Apollo On-Board Flight Software Contributions.	$100 billion+
MSC-23600-1	NASGRO Fracture Mechanics Analysis Software	$1 billion+

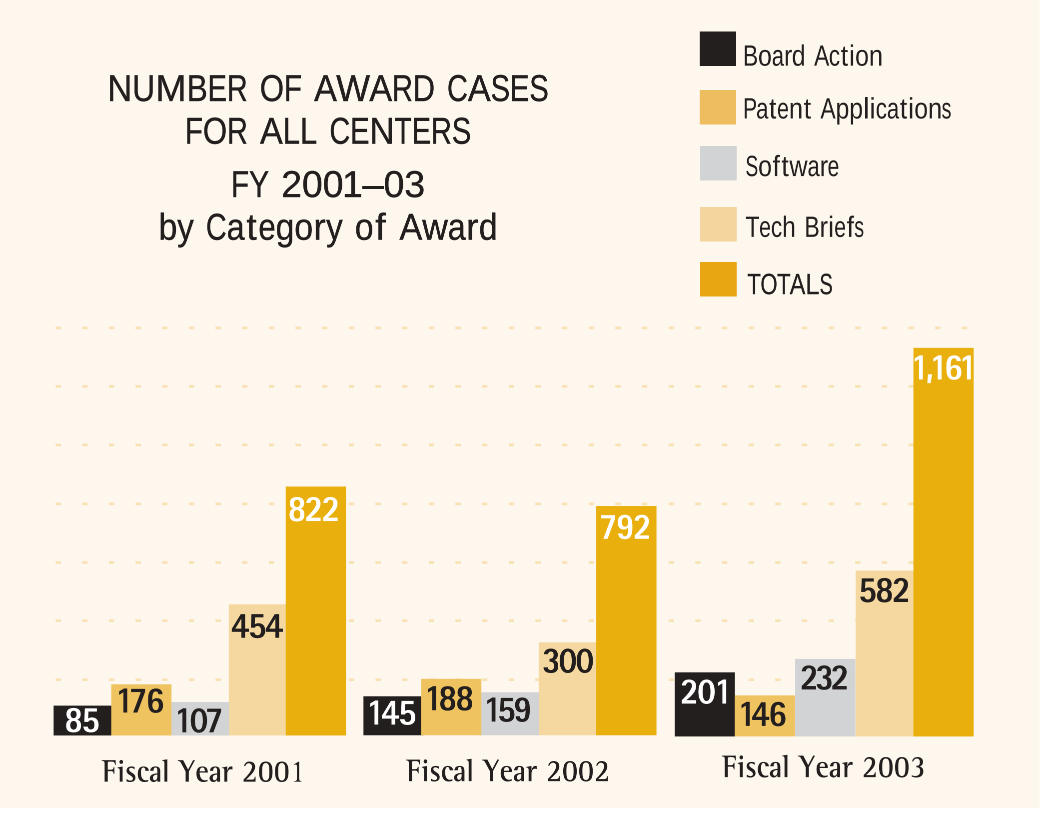
NASA's Space Act Awards Granted in 2003

This year's Space Act Award leaders include the following:

- Tech brief awards: JPL with 244
- Software release awards: JPL with 69
- Patent application awards: JSC with 23
- Board action awards: JPL with 111

During FY 2003, NASA granted over 2,700 Space Act awards to innovators who produced significant scientific and technological solutions to problems relating to aeronautics and space activities. The total amount awarded was just over $1.6 million, including over $500,000 paid to NASA employees and retirees. JPL, for the fourth year in a row, led all NASA Centers and facilities with 1,157 awardees receiving more than $620,000. Kennedy Space Center, also for the fourth year in a row, led all civil service Centers with 316 awardees receiving nearly $200,000. Glenn Research Center led all civil service Centers with 137 total technology award cases. Totals by category for FY 2001–03 are shown in the figure below.

Full details on this year's performance are available on the ICB Web site: *http://icb.nasa.gov/ICB_Metrics*



NASA's Exceptional Space Act Awards in 2003

The ICB considers any case whose value to the United States is judged to be high enough that at least one contributor receives $5,000 or more as "exceptional." There have been only 128 such cases since 1990. The following nine cases achieved this honor in FY 2003:

Apollo On-Board Flight Software Contributions $37,200

Margaret Hamilton, HTI

Building Blocks for Software Engineering

The Apollo flight software was one of the earliest successful, most significant developments of flight software as we know it today. It was a pioneering effort that performed exceptionally for Apollo. The concepts developed became the building blocks for modern "software engineering," a term coined by Ms. Margaret Hamilton of HTI, and immediately found use beyond Apollo on Skylab and Shuttle. Her concepts of asynchronous software, priority scheduling, software reuse, and man-in-the-loop decision capabilities such as priority displays became the foundation for ultrareliable software design. Many examples can be cited of successful implementation on Apollo. The most important example is from Apollo 11. On July 20, 1969, 3 minutes before the Eagle's touchdown on the Moon, the software overrode a command to switch the flight computer's priority processing to a radar system whose "on" switch had been manually activated because of a faulty written operations script provided to the pilot. If the software override had not been active, preprogrammed, tested, and simulated, the Lunar Excursion Module (LEM) landing might have been aborted or the LEM could have crashed on that fateful day, possibly killing the astronauts and jeopardizing the human space flight program. The 40,000-line LEM code and its matching code for the Service and Command Modules were written under contract to Charles Stark Draper Labs, under the direct design control of Ms. Hamilton. Her unique ideas included using priority displays, establishing hard requirements on the engineering of all components and subsystems to eliminate interface errors with the flight software at the systems level, debugging all components and testing before assembly, and simulating every conceivable situation at the systems level before releasing the code. This process made it possible to identify potential anomalies and resulted in ultrareliable code. No software bug was ever found on any Apollo mission. Ms. Hamilton demanded that the flight code be designed to work right the first time: "There was no second chance." Apollo lives on today, continuing to impact the modern world in part through the many innovations created and championed by Ms. Hamilton.

Margaret Hamilton, the lead Apollo flight software designer (shown here in a mock-up of the Apollo Command Module), is considered to be the pioneer of the field of software engineering. (Photo courtesy of the Massachusetts Institute of Technology)

2002 NASA Government Invention of the Year

Computer Implemented Empirical Mode Decomposition Method

$44,800 ($8,200 additional award)

Norden Huang, Goddard Space Flight Center, Goddard Institute for Data Analysis

Empirical Mode Decomposition, also known as the Hilbert Huang Transformation (HHT), is the 2002 NASA Government Invention of the Year. The HHT method has proven its versatility and value at NASA and throughout the Government. The HHT method is currently used by the Laboratory for Hydrospheric Sciences at Goddard Space Flight Center (GSFC) to analyze sea surface temperature data collected by the NASA Nimbus 7 Scanning Multichannel Microwave Radiometer. The HHT has been used on images collected by the National Oceanographic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) sensor. There are known artifacts in the data collected due to a drift of 1 to 2 hours in local overpass time of the satellite. The HHT is being used in the data post-processing mode to correct the data. HHT has also proven successful in connecting environmental changes to El Niño phenomena. Another successful application of HHT is the fusion of data between different sensors; in particular, fusion between data from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project and AVHRR. The Laboratory for Terrestrial Physics at Goddard is also applying the HHT to numerical simulations in fluid dynamics. The time history of a given point in a flow is a one-dimensional data set, which the HHT is being used to analyze. Since fluid dynamics is a nonlinear process, this transform offers insight beyond that possible with standard Fourier methods. It has also been used for voice identification in law enforcement, such as for cell phone intercepts.

2002 NASA Commercial Invention of the Year

Video Image Stabilization And Registration (VISAR)

$23,000

David Hathaway and Paul Meyer, Marshall Space Flight Center

The Video Image Stabilization and Registration (VISAR) is the 2002 NASA Commercial Invention of the Year. VISAR does what other image stabilization processes cannot do: it corrects for changes in orientation and size. In its current usage, VISAR takes just seconds to do what Hathaway and Meyer took days to do before its invention, and it does a better job. This capability is critical for many video applications that arise in aerospace, commercial, consumer, and Government operations. It has played a critical role in specific applications within solar physics research, forensics, and medical research. Without VISAR, the usefulness of the video data in these investigations would have been severely compromised. VISAR was a vital tool in the Columbia investigation.

The SeaWiFS Data Analysis System (SeaDAS) $35,450

Gene Carl Feldman, Charles McClain, Goddard Space Flight Center; Karen Baith, consultant; Mark Reubens, Xiao-Long Wang, Gary Fu, Bryan Franz, SAIC

2003 NASA Software of the Year
Cowinner

Cowinner of the 2003 NASA Software of the Year competition, the SeaWiFS Data Analysis System (SeaDAS) maximizes NASA's investment in Earth remote sensing and delivers data to the user community in a timely manner with the tools to manipulate the data consistently and accurately. SeaDAS provides data display, processing, and analysis support. SeaDAS was designed to reproduce identically all the standard products, including levels 1, 2, and 3 (raw telemetry counts to level 3 global mapped geophysical products), generated by the SeaWiFS Project Office (SPO) while providing users, through open-source development, with the flexibility of customized processing by adjusting processing parameters or selecting alternative processing methods. SeaDAS is in use at over 500 sites in over 50 nations.

NASGRO(TM) Fracture Mechanics Analysis Software $35,450

Royce G. Forman, Johnson Space Center; Leonard Williams, GB Tech; Joachim Beek, Sambi Mettu, Venkataraman Shivakumar, Feng Yeh, Lockheed Martin; Joseph W. Cardinal, Craig McClung, Southwest Research Institute

2003 NASA Software of the Year
Cowinner

Cowinner of the 2003 NASA Software of the Year competition, NASGRO is the internationally accepted standard code for fracture control analysis of space hardware. The code has important use on the Space Shuttle and the International Space Station (ISS) Programs, including the analysis of payloads and resolution of crack-like anomalies. Over 1,700 users of NASGRO are identified, representing over 600 companies and including space, civil aviation, military, and university communities. NASGRO is the standard code for fracture analysis of space hardware, aircraft, rotorcraft, turbine engines, and many other pieces of mechanical equipment.

The SeaWiFS Data Analysis System (SeaDAS) and NASGRO Fracture Mechanics Analysis Software are both recipients of the Software of the Year Award for 2003.

Complete Performance Prediction in One Program

SRGULL Analysis Code for Ramjet/ Scramjet Engine/Hypersonic Vehicle Design and Performance $18,800

S. Zane Pinckney, Swales Aerospace; Shelly M. Ferlemann, Langley Research Center; Laura S. Bass, SAIC

The SRGULL computer program is a vehicle aerodynamics/subsonic/supersonic combustion engine cycle code. SRGULL predicts the vehicle aerodynamics and the engine flow path performance of airframe integrated ejector ramjets, ramjets, dual-mode ramjets, scramjets, and ejector scramjets in either nose-to-tail or cowl-to-tail accounting systems and in either body or flight coordinates. In one program, SRGULL provides complete vehicle and engine integration prediction capability to enable the performance prediction and optimization of airframe integrated ramjet/scramjet engine flow-path design for hypersonic airbreathing vehicles. It provides a method to predict vehicle aerodynamics and ramjet/scramjet engine performance for the highly integrated vehicle/scramjet/ramjet system with minimal input in order to evaluate new hypersonic vehicle ideas quickly and cheaply. SRGULL has been used in the X-43 and Hyper-X programs and in 21 other programs and studies for missiles, hypersonic planes, and gun-launched projectiles.

Massive Data-Analysis Tool for Desktop PCs

WinPlot $5,000

J. Roger Moody, Marshall Space Flight Center

WinPlot is a desktop data-analysis tool that allows the user to generate displays of unrestrictive amounts of data for detailed analysis. WinPlot was developed to satisfy the need for fast and easily manageable graphical displays of propulsion test and flight data (both predicted and actual) in a desktop computer environment. It is capable of manipulating massive amounts of data on a desktop PC. Data can be accessed in posttest as well as in real time, displaying more than 1,000 post-test files at a time. Data may be analyzed with more than 1,000 curves per plot, including multiple graph-views.

Personal Cabin Pressure Altitude Monitor and Warning System $19,100 ($7,100 additional award)

Jan A. Zysko, Kennedy Space Center

Lifesaving Warning System for Crewmembers

A depressurized cabin on aircraft or any human-tended space vehicle (like the Station or Shuttle) or planetary habitat (lunar or Mars base) due to a pressurization system failure, vehicle impact/damage, or errant system configuration is not only possible, but has actually happened all too often over the years—sometimes with fatal consequences. The Payne Stewart Lear Jet crash in 1999, the Progress/Mir collision in 1997, and the Apollo 13 oxygen tank explosion in 1970 are highly visible examples of times when pressurization systems have impacted the mission and endangered or taken the lives of crewmembers and/or passengers. When a depressurization event happens with the crew unaware of the situation, such as in a slow but significant leak, hypoxia can render the crew helpless in short order. The cognitive and mental ability is affected first, followed by physical incapacitation, and then unconsciousness or even death. The purpose of the Cabin Pressure Monitor is to provide a timely warning to the crewmembers while they are still mentally and physically able to take corrective/protective action. This device is licensed to Kelly Mfg., the world's largest producer of general aviation instruments, for use in aviation and for ground applications such as mountain climbing or precise altitude measurements taken by utility companies.

Protective Coating for Ceramic Materials (PCCM) $11,100

Demetrius Kourtides, Rex Churchward, David Lowe, Ames Research Center

Environmentally Friendly Heat & Fire Protection

The innovation PCCM is a coating material consisting primarily of colloidal silica and other high-emissivity agents. The coating is water-based and, therefore, environmentally friendly. The coating provides heat and fire protection to many substrates such as ceramic, wood, and metal. PCCM can easily be applied by spraying, brushing, or via doctor blades (blades commonly used to apply an even layer of inks or coatings to a surface), or it can be incorporated as a constituent in wood or plastics. The coating can be used on any type of material—rigid, flexible, or fabric. Although the surface of the substrate must be at ambient temperature during the coating process, the coating typically dries within 1 to 2 hours, depending on humidity and temperature conditions.

ICB members and staff (from left): Caleb M. Principe, GSFC; Dr. Clyde F. Parrish, KSC; Dr. Paul A. Curto, HQ (ICB Senior Technologist); Reginald (Reg) Mitchell, GSFC; Dr. Anngienetta Johnson, HQ; Dr. Donald C. Braun, GRC; Sandra A. Cauffman, GSFC; Pamela R. Rinsland, LaRC; Theron M. Bradley, Jr., HQ (Chair); Diane M. Stoakley, LaRC; Harry Lupuloff, HQ (ICB Counsel); Walter D. Hussey, HQ (ICB Staff Director); Carey F. Lively, GSFC; Alan J. Kennedy, HQ; Benjamin Neumann, HQ (former Staff Director); Gail M. Sawyer, HQ (Recording Secretary); Lawrence P. Chambers, HQ; and Dr. J. Steven Newman, HQ. Not pictured: Dr. Biliyar N. Bhat, MSFC, and Keith Hudkins, HQ (Vice Chair).

Awards Liaison Officers and the ICB

The ICB members and the Awards Liaison Officers at NASA's Centers work as a team to reward NASA's technology community leaders. The people behind the ICB awards are shown.

Awards Liaison Officers (from left): Laurie Stauber, GRC; Betsy Robinson, ARC; Chris Jaggers, JPL; June Rosca, NMO/JPL; John Childress, DFRC; Dale Hithon, GSFC; Jesse Midgett, LaRC; John Bailey, SSC; Abbie Johnson, MSFC; Jim McGroary, MSFC; and Carol Dunn, KSC. Not pictured: Duane Ross, JSC, and Jeannette Scissum, HQ.

For More Information

Information about the ICB and its programs may be viewed at the NASA Web site: *http://icb.nasa.gov*.

The lead contact for the Inventions and Contributions Board is Walter D. Hussey, ICB Staff Director, 202.358.0591.

Questions on the NASA Space Act Awards Program may be addressed to Dr. Paul A. Curto, ICB Senior Technologist, 202.358.2279.

The key contact in the process for an application for patent waiver, and for advance patent waivers, is Ms. Gail M. Sawyer, ICB Program Specialist, 202.358.1637.